

BOEING PROPRIETARY

## INVENTION DISCLOSURE

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This form is to be used for disclosure to The Boeing Company of inventions, discoveries, improvements or innovations, whether or not considered patentable.  
See above for instructions.

## TITLE OF INVENTION (Descriptive and Concise)

Super Plastic Rivet Material.

## INVENTOR INFORMATION (Use Additional Sheet if Necessary)

INVENTOR NAME (FIRST, M.I., LAST) 1	INVENTOR NAME (FIRST, M.I., LAST) 2	INVENTOR NAME (FIRST, M.I., LAST) 3	INVENTOR NAME (FIRST, M.I., LAST) 4
Edward Litwinski	Rahmat F. Toosky		
SOCIAL SECURITY NO. [REDACTED]	SOCIAL SECURITY NO. [REDACTED]	SOCIAL SECURITY NO.	SOCIAL SECURITY NO.
ORG. NO. [REDACTED]	MAIL STOP [REDACTED]	ORG. NO. [REDACTED]	MAIL STOP [REDACTED]
PHONE [REDACTED]	PHONE [REDACTED]	PHONE	PHONE
BOEING EMPLOYEE (ADD SUBSIDIARY) <input type="checkbox"/> Boeing <input type="checkbox"/> MDC <input checked="" type="checkbox"/> BNA <input type="checkbox"/> CONTRACT EMPLOYEE <input type="checkbox"/> OTHER (SPECIFY)	BOEING EMPLOYEE (ADD SUBSIDIARY) <input type="checkbox"/> Boeing <input checked="" type="checkbox"/> MDC <input type="checkbox"/> BNA <input type="checkbox"/> CONTRACT EMPLOYEE <input type="checkbox"/> OTHER (SPECIFY)	BOEING EMPLOYEE (ADD SUBSIDIARY) <input type="checkbox"/> Boeing <input type="checkbox"/> MDC <input checked="" type="checkbox"/> BNA <input type="checkbox"/> CONTRACT EMPLOYEE <input type="checkbox"/> OTHER (SPECIFY)	BOEING EMPLOYEE (ADD SUBSIDIARY) <input type="checkbox"/> Boeing <input type="checkbox"/> MDC <input type="checkbox"/> BNA <input type="checkbox"/> CONTRACT EMPLOYEE <input type="checkbox"/> OTHER (SPECIFY)
MANAGER'S NAME C.E. Silverman	MANAGER'S NAME C.E. Silverman	MANAGER'S NAME	MANAGER'S NAME
PHONE [REDACTED]	PHONE [REDACTED]	PHONE	PHONE

## STATE OF DEVELOPMENT (See Remarks On Back)

DATE CONCEIVED [REDACTED]	<input type="checkbox"/> CONCEPT ONLY <input type="checkbox"/> PROVEN ANALYTICALLY <input type="checkbox"/> DESIGN COMPLETE	DATE BUILT [REDACTED]	DATE SATISFACTORILY TESTED [REDACTED]	<input type="checkbox"/> PROTOTYPE <input type="checkbox"/> IN PRODUCTION _____ DATE
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## APPLICATION OF THE INVENTION

PRODUCT/PROGRAM All riveted aluminum products	PRODUCTION RELEASE E.G. PRR NO.	DATE
POTENTIAL CUSTOMER(S) IN ADDITION TO BOEING [REDACTED]		

## DISCLOSURE OF INVENTION OUTSIDE BOEING

DISCLOSED TO: <input type="checkbox"/> VENDOR <input type="checkbox"/> CUSTOMER <input type="checkbox"/> OTHER	NAME(S) None at this time	DATE(S)
PUBLISHED <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	PUBLICATION NAME	DATE
	VOLUME NO.	PAGE

## DEVELOPMENT HISTORY

1. WHAT BOEING ACCOUNT OR WORK ORDER WERE YOU CHARGING TO WHEN YOU MADE THIS INVENTION?  
ACCOUNT OR WORK ORDER NO. FOR EACH INVENTOR (16-DIGIT CHARGELINE) 1) Personal Time  
2) \_\_\_\_\_ 3) \_\_\_\_\_ 4) \_\_\_\_\_
2. CHECK AS APPLICABLE:
- ☐ THIS INVENTION WAS CONCEIVED OR FIRST BUILT AND TESTED IN THE COURSE OF WORK UNDER A U.S. GOVERNMENT CONTRACT.  
CONTRACT NO. OR OTHER IDENTIFICATION \_\_\_\_\_
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- ☐ THE FOLLOWING ADDITIONAL PARTIES MAY HAVE RIGHTS TO THIS INVENTION: \_\_\_\_\_
3. RELATED INVENTION DISCLOSURE NOS: \_\_\_\_\_

DO NOT WRITE BELOW THIS LINE

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**Introduction:** Briefly introduce the subject associated with your invention.

Due to a lack of formability of high strength aluminum alloys in the hardened condition, a rivet manufacturing requires forming the rivet head in a soft condition, heat treating the rivet. Although there are a wide range of material issues associated with rivet material selection, the predominant factors are the materials bucking ability (formability) and the shear strength. There are many aluminum alloys with desirable shear strength, however, they tend to fracture during installation.

The friction stir weld process produces an ultra fine grain structure in the "nugget" area of the weld. Testing had determined that this nugget material has superior formability. Formability is known to be dependant on grain size. For example, as an indication of formability, the typical elongation of 2219-T4 is 20%. The elongation for 2219-FSW material was measured up to 29% and the 2195-FSW material was measured up to 21.5%. The increase in % elongation means an increase in formability of an alloy. This also applied to aluminum alloys with directional properties, for example the 2195 alloy, that have a lack of formability. Additional benefits include increased fatigue life, corrosion resistance and fracture toughness that should be applicable to all aluminum alloys, i.e. 2219, 2195, 7050, 7075 and 2017.

**Problem Solved By This Invention:** State the existing problem that is solved by your invention.

Response: The rivet manufacturing process can be shortened using fine-grain material instead of an annealed material. The rivet would be used in the "as-formed" condition. This would reduce the rivet manufacturing costs as well as eliminating the possibility of rivets being heat treated improperly.

Additionally, conventional mill products have limited formability, toughness and corrosion resistance. Lack of formability results in rivet cracking during forming operations. A lack of fatigue strength results in rivet fatigue cracks while in service. A lack of corrosion resistance results in premature failure.

**Background:** Describe the approaches that are currently used to solve or mitigate the existing problem. Additionally, describe the shortcomings associated with these approaches. Include any related patents or publications that you have knowledge of.

Response: Softer, lower strength material have been used to avoid cracking. The dimension or upset of the head is controlled to reduce cracking.

The rivets are typically coated for improved corrosion resistance.

**Invention Description:** Provide a detailed description of your invention, and illustrate it in a drawing, sketch, or a schematic (if susceptible to illustration). Correlate the illustration with the description by

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SIGN	<i>Kevin Ruth</i>	[REDACTED]			SIGN	<i>Edward L. [REDACTED]</i>	[REDACTED]	[REDACTED]
PRINT	Kevin Ruth				PHONE	[REDACTED]	SIGN	<i>Rahmet Hoo [REDACTED]</i>
SIGN	<i>[REDACTED]</i>	[REDACTED]			SIGN			
PRINT	RUDY LAURETTA				PHONE	[REDACTED]	SIGN	
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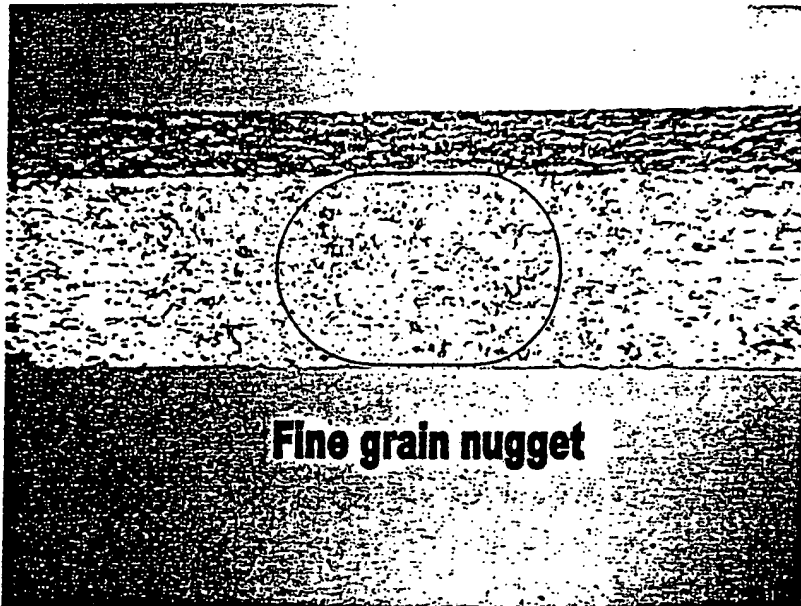
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using reference numerals and/or letters. Most importantly, clearly state the novelty of your invention (to the best of your knowledge). The invention description is likely to require more than one page of information.

Response: Testing had determined that the FSW nugget material has superior characteristics as a rivet material, such as increased toughness, increased fatigue life and increased corrosion resistance.

A load vs. displacement compression curve of 2219 and 2195 -T6 FSW nugget materials illustrated that these materials had much greater formability than materials presently produced.

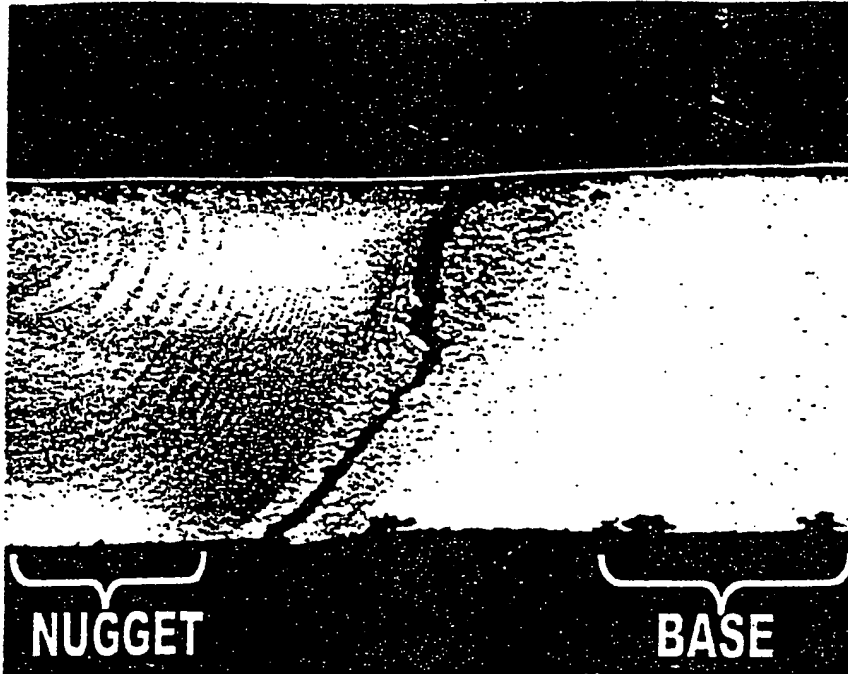
Corrossion testing of a FSW specimen had determined that the nugget was less susceptible to corrossion than the base material. A cross section through a 2219-T6 tensile specimen that had been previously exposed to 90 days of alternate immersion testing determined that the nugget area had the least amount of corrosion attack. The maximum depth of pitting and intergranular attack in the unaffected base metal was twice as deep as the nugget material.



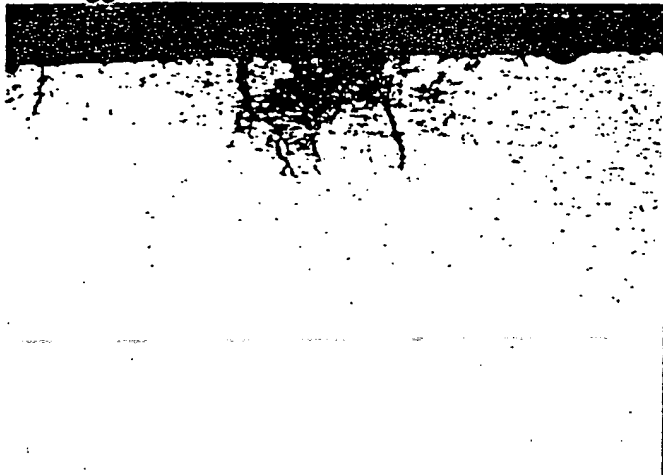
Overall view of 2219 tensile specimen after 90 days of alternate immersion testing. Circle indicates nugget area.

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PRINT Kevin Ruth					SIGN <i>Rahmat Noor</i>			
SIGN <i>Rudy Lauchetta</i>	PHONE				SIGN			
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View of cross section through 2219-T6 FSW tensile specimen (after testing). Note the area annotated as the nugget area has less corrosion as the base metal.



Detailed view of nugget metal corrosion.



Detailed view of base metal corrosion.

**Technical Maturity:** What is the state of development? Provide evidence that your invention concept has been sufficiently developed that there is little technology risk associated with its implementation. Results from analysis, simulation/modeling, or prototype testing are preferred.

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PRINT	Kevin Ruth				PHONE	[REDACTED]	SIGN	
SIGN	<i>Rudy Lauricella</i>	[REDACTED]			SIGN			
PRINT	RUDY LAURICELLA				PHONE	[REDACTED]	SIGN	
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Response: Bucking ability on 2219 and 2195 FSW nugget materials determined that they had a desirable "upsetting" characteristics far beyond the traditional rivet materials. The tests showed that the rivets also had good hole filling characteristics and shear strength.

**Technical Value:** Provide evidence that your invention represents a significant advance in a technology area important to the success of Boeing, whether or not currently used. Quantitative data, such as trade study results, supporting the claimed benefits of your invention are preferred.

Response: Boeing is a major aerospace user of riveted products. The use of superior rivets will favorably affect the quality of our products. The formability and material properties is a significant improvement in the alloy without any weight gain. The ultra fine grained rivet material can be substituted for conventional rivet alloys without requiring a drawing changes. Present specifications permit this.

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SIGN	<i>[REDACTED]</i>	[REDACTED]			SIGN			
PRINT	Rudy Lauretta				SIGN			
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PRINT	Kevin Ruth				SIGN <i>Robert F. Ood</i>	
SIGN	<i>Rudy Lauretta</i>				SIGN	
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PRINT	Kevin Ruth	PHONE [REDACTED]			SIGN		<i>John at Rocky</i>	[REDACTED]
SIGN	<i>Rudy Lauretta</i>	[REDACTED]			SIGN			
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